SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR MAY, 1917.

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GENERAL PRESSURE DISTRIBUTION OVER THE NORTHERN HEMISPHERE, EXCEPT EUROPE AND INTERIOR ASIA.

Over the northeastern portion of the North Pacific Ocean pressure was moderately low during the first two weeks of May, 1917, and moderately high during the second two weeks, followed by a falling tendency during the last three days of the month. These same conditions prevailed generally over the southeastern portion of the North Pacific Ocean, as indicated by the pressure at Honolulu. Over the northwestern portion of the North Pacific low pressure prevailed continuously. Marked low pressure conditions were also reflected later in the month over the northeastern portion of the North Pacific, but during the first two weeks high pressure prevailed over this section and extended over northern and central Alaska, continuing throughout the month with only a single interruption on the 18th and 19th. Over southern Alaska pressure was variable during the first 20 days of the month within quite narrow limits, but during the remaining days it was moderately high.

In the Pacific States there were alternating periods of pressure slightly above and slightly below the normal, each of several days duration as a rule, but none of great consequence.

Over the interior of the United States proper, from the Mississippi Valley westward, moderately high pressure prevailed almost uniformly during the first half of the month, while during the second half of the month low pressure ruled, with occasional intervals of pressure slightly above normal. To the eastward low pressure prevailed throughout practically the entire month; it was of abnormal persistence and extended over the entire eastern Canadian Provinces, markedly so over eastern Newfoundland. The last 10 days of the month were characterized by a series of disturbances of the Colorado type that move eastward and northeastward south of the high-pressure area, attended by widespread precipitation and severe local storms, with many disastrous tornadoes.[1]

Over the North Atlantic Ocean pressure was also generally low during the first half of the month and slightly above normal during the second half over the north portion, and about normal over the southern portion. The persistence of the western and northwestern high pressure and the southern low pressure, coupled with the prevailing low pressure over the Atlantic Ocean, furnished a satisfactory explanation of the abnormally low temperatures that prevailed during much of the month.

STORM WARNINGS.

While there were no great storms during the month, there was a considerable number that required the display of storm warnings, specially the series of storms of the Colorado type that prevailed during the last 10 or 12 days of the month.

[1] For an extended and illustrated discussion of the weather conditions accompanying these storms and tornadoes see the REVIEW for June, 1917.

At the close of April storm warnings were displayed on the Great Lakes, a disturbance of marked intensity being central over that region. On the morning of May 1 warnings were changed to northwest for Lakes Michigan, Huron, and western Erie, and northwest warnings were ordered hoisted on northeast Lake Huron. Moderately strong winds occurred during the day and night following, except on Lake Michigan, where there were no high winds during the night and the warnings were accordingly lowered at 9 p. m. This storm also caused some moderately high winds of some duration along the New England coast during the night of the 1st, but they were not of a character sufficient to justify storm warnings.

On the morning of the 4th a southwestern disturbance was central over eastern Kentucky with a rather rapid northeastern movement, and accordingly southeast storm warnings were ordered at 11 a. m. from Hatteras, N. C., to Philadelphia, and northeast warnings northward to Portsmouth, N. H., with the information that the easterly winds would become strong and shift to west on the following day. During the next 24 hours fresh to strong northeasterly gales prevailed along the southern New England, New Jersey, and Delaware coasts, but there was nothing of consequence to the southward, the disturbance having diminished in energy and dividing into two sections. Northeast storm warnings were also ordered at 10:30 a. m. of the 4th on the Lower Lakes, strong northeast to north winds with rain or snow having been indicated. Only fresh to moderately strong northwest winds occurred.

On the morning of the 5th, with the bifurcated disturbance over western Pennsylvania and eastern North Carolina, the northeast storm warnings were continued from Sandy Hook to Portsmouth, N. H., and extended along the coast of Maine. Strong northeast winds occurred as forecast and continued until after the morning of the 6th.

On the morning of the 7th a disturbance that apparently moved from Arizona to the mouth of the Rio Grande and thence northeastward was central over northeastern Gulf of Mexico. Special observations indicated an increasing intensity of the disturbance, and accordingly at 3 p. m. northeast storm warnings were ordered from Charleston, S. C., to the Virginia Capes, and at 10 p. m., with the disturbance central on the South Carolina coast, the northeast warnings were extended northward to New York. On the morning of the 8th the storm was central near the North Carolina coast, with considerably increased intensity, and the northeast storm warnings were therefore extended northward along the New England coast from Bridgeport, Conn., to Boston. During the night of the 7th and on the 8th strong northeast to north winds prevailed from the South Carolina coast northward to Delaware. As the storm moved northeastward at a considerable distance from the coast, there were no strong winds north of the Delaware Capes until the 9th, and then only on the coast of Maine, where they continued until sometime during the night of May 10–11. Northeast storm warnings had been ordered along the eastern Maine coast at 12:30 p.m. of the 9th, and on the morning of the 10th the storm was central over Nova Scotia, with a barometer reading of 28.96 inches at Halifax.

On the morning of May 19 there was a well-defined disturbance over Wisconsin and upper Michigan, and as midday observations indicated a further development with an eastward movement, southwest storm warnings were ordered at 2:30 p. m. displayed from Harbor Beach to Oswego, N. Y., strong south and south west winds and thundersqualls being indicated. These occurred as forecast with wind velocities ranging as high as 56 miles an hour.

On the morning of the 21st another storm from the southwest was central over central Kansas with a northeastward movement, and small-craft warnings were ordered at 10 a. m. on Lakes Michigan, Huron, and Erie, and northeast storm warnings on Lake Superior from Duluth to Houghton. Special observations showed the rather rapid movement of the storm with increasing energy, and at 3 p. m. northeast warnings were ordered for the balance of Lake Huron while the warnings elsewhere on the Lakes, as far east as Erie, Pa., were changed to northeast. During the next 24 to 36 hours strong winds occurred as forecast, except on southern Lake Huron, where they were only fresh. On the morning of the 22d, with the storm central over Illinois, southeast warnings were ordered from Buffalo to Oswego for increasing east to south winds that would become strong and shift to north and northwest on the following day with gale force. Again the winds occurred as forecast, with a maximum velocity of 68 miles an hour from the southwest at Buffalo. At 3 p. m. of the 22d the warnings were changed from northeast to northwest on eastern Lake Superior, Lake Huron, and western Lake Erie, as strong northwest winds were indicated; they occurred during the succeeding 24 hours.

As this storm was not moving very far to the northward, southwest warnings were also ordered at 3 p. m. on the 22d from Tybee Island, Ga., to Eastport, Me., and moderately strong winds occurred as forecast.

On the morning of the 23d with the storm central over Ontario, the southeast warnings that were displayed from Buffalo to Oswego were changed to southwest; the southwest warnings on the Atlantic coast from Sandy Hook, N. J., to Nantucket were changed to northwest; and southwest warnings were continued on the New England coast north of Nantucket. At 3 p. m. of the 23d the southwest warnings from Buffalo to Oswego were changed to northwest and continued at 3 p. m. of the 24th. Southwest storm warnings were also ordered on the Atlantic coast from Delaware Breakwater to Atlantic City; but by the night of the 24th the storm had reached the St. Lawrence Valley with much decreased intensity, and all warnings were therefore lowered after a two-day period of strong winds.

On the morning of the 26th another storm of the western series was central over northwestern Iowa, and at 10:30 a. m. northeast storm warnings were ordered for Lake Superior and southeast warnings for Lake Michigan and northern Lake Huron. At 3 p. m. the southeast warnings were extended over southern Lake Huron and western Lake Erie, and at 10 p. m. over eastern Lake Erie and Lake Ontario, at which time the storm was central over Illinois with somewhat decreased intensity. Owing to the fact that another storm from the southwest closely followed this storm, there were no winds of consequence, nothing more than fresh winds having been recorded. On the morning of the 27th the second storm referred to in the preceding sentence was central over Oklahoma, and northeast warnings were ordered at 10:30 a. m. on Lakes Michigan and Huron, and on Lake Erie from Detroit to Toledo. This storm passed over the Ohio Valley, and as no strong winds were indicated at the time, the warnings were ordered down at 10 p. m. of the 27th on Lake Michigan and on Lake Huron from Saginaw northward. However, at 8 p. m. of the 22d the storm was central over southern Illinois in such formation as to indicate an increase in intensity, and northeast warnings were therefore ordered from Sandusky to Oswego, N. Y., warnings still being displayed south of Saginaw as far as Toledo. Owing to the absence of a decided rise in pressure to the westward of this disturbance, no strong winds occurred.

On the morning of the 28th, with the storm central over southwestern Ohio, northeast warnings were ordered from Delaware Breakwater to Portland, Me., and southeast warnings from Baltimore to Charleston. The warnings were generally verified by the occurrence of strong winds and gales, Norfolk, Va., reporting a velocity of 60 miles from the southwest during the afternoon of the 28th. On the morning of the 29th, when the storm was central off the southern New England coast, the northeast warnings were extended along the Maine coast, east of Portland, and fresh gales occurred during the following 24 hours.

On the morning of the 30th still another of the southwestern storms was central over eastern Kentucky, and at 10:30 a. m. southeast warnings were ordered for Lakes Michigan and Huron, and small-craft warnings on Lake Superior. Special midday observations indicated the necessity of an extension of the warnings, and at 3 p. m. southeast warnings were ordered on Lake Erie from Detroit to Erie. The warnings for Lake Erie were justified, while those for Lake Michigan and Huron failed. On the morning of the 31st, with the storm central over southern Wisconsin, the Lake warnings were extended from Buffalo to Oswego, but only moderately strong winds occurred. The warnings on Lakes Michigan and Huron were also changed to southwest and northwest at 10:30 a. m. of the 31st, and small-craft warnings ordered on Lake Superior, but by evening it was apparent that no strong winds would occur, and the warnings were accordingly lowered at 9 p. m.

FROST WARNINGS.

Frost warnings were ordered almost daily for some section during the first two weeks of the month and others might have been ordered so far as indications of coming frost were concerned, but as the lateness of the season precluded any damage of consequence they were not ordered. This latter statement applies more directly to the Upper Lakes region, where heavy to killing frosts occurred quite often during the first two weeks of the month. Over other sections in the Washington forecast district frosts were not of consequence.

The coldest weather of the month in the Upper Lakes region occurred on May 23, when freezing temperatures and snows were quite general.

WARNINGS FROM OTHER DISTRICTS.

Chicago forecast district.—On the morning of May 1, frosts being general in the Plains States and the Missouri Valley, warnings were issued for portions of Illinois, Wisconsin, Iowa, and North Dakota, and on the morning of the 2d for eastern Wisconsin. These warnings were verified as a rule. On the 4th a disturbance was central over Tennessee, moving eastward, while high pressure and

abnormally low temperature prevailed in the States to the west and north. Frost warnings were issued for Illinois, Missouri, Iowa, Wisconsin, and extreme eastern Kansas, and were generally verified. Warnings were issued each day from the 5th to 13th, inclusive, for some portion of the upper Mississippi Valley or western Lakes region, and were partially verified. No further warnings of importance were issued until the 22d, when they were issued for Iowa, Wisconsin, and southeastern Minnesota. Frost occurred the following morning throughout the upper Mississippi Valley and western Lakes region. On the 23d, 24th, and 27th warnings were sent to the Wisconsin cranberry marshes. Warnings which were issued for portions of the Dakotas, the upper Mississippi Valley, and the western Lakes region on the 30th and 31st were not verified.—*Chas. L. Mitchell, Assistant Forecaster.*

New Orleans forecast district.—On the 29th the p. m. map showed an area of low pressure of some intensity central over extreme northwestern Texas. Southeast storm warnings were ordered for the Texas coast and were verified.

Frost warnings for extreme northwestern Oklahoma and the Texas Panhandle were issued on the 3d; for northwestern Arkansas and northeastern Oklahoma, on the 4th; for Arkansas, on the 5th, with warning of freezing in the Texas Panhandle; for Arkansas, Oklahoma, and northern and extreme western Texas, on the 6th, with warning of heavy frost in Oklahoma, northern Arkansas, and northwestern and extreme western Texas, and freezing in extreme northwestern Oklahoma and the northern portion of western Texas; for northern Arkansas and northeastern Oklahoma, on the 7th; for Arkansas and northeastern Oklahoma, on the 8th; for the Texas Panhandle and extreme northwestern Oklahoma, on the 11th; for northwestern Oklahoma and the northern portion of western Texas, on the 27th. The warning of the 6th was verified over the greater portion of the indicated area. At El Paso, Tex., the lowest May temperature of record, 44°F., was recorded. A slight rise in temperature prevented the verification of warnings for the 11th and 27th. All other warnings were justified.—*R. A. Dyke, Assistant Forecaster.*

Denver forecast district.—May, 1917, was characterized by a winter-like distribution of pressure; in fact, the weather of this month was more unsettled and unpleasant than in the average winter month. Storms developed in rapid succession in the western part of this district, and in not a few instances a new storm formed before the preceding storm had passed eastward beyond the district. The storms invariably crossed the district and generally in the southern part so that in addition to frequent precipitation there was a remarkable persistency of unseasonably cold weather.

On the morning of May 2 low pressure prevailed from Utah southeastward to central Texas, while moderately high pressure overlay the Pacific Northwest. Warnings of frost were issued for western Utah. Frosts occurred throughout Utah. On the 3d warnings of frost were issued for Colorado and northern New Mexico, the pressure at the time being lowest in Texas with isobaric loops extending westward to Arizona, while moderately high pressure prevailed north of the district. Frosts occurred in the area designated. In the Grand Valley fruit district the lowest temperature reported was 27° at Loma, and in the Gunnison fruit district, 26° at Paonia. On the 4th the pressure was relatively low west of the Continental Divide and high in the Pacific Northwest. Local frosts were forecast for Utah.

On the 5th freezing temperature was forecast for Colorado and northern New Mexico and occurred as forecast; the lowest temperatures reported were: From the Grand Valley, 27° at Palisade; in the Gunnison district, 21° at Spring Creek and 26° at Santa Fe. At the time the forecast was issued low pressure prevailed in New Mexico and high pressure north of the district; the LOW was forced southward by the northern high pressure which moved to eastern Colorado, increasing in intensity. Warning of freezing temperature was therefore continued for eastern Colorado and New Mexico and warning of frost or freezing temperature for western Colorado. For El Paso the predicted minimum was 38°, and for Roswell, N. Mex., 28°. Reports of the following morning showed the minimum temperatures of 38° and 28°, respectively, both of these readings being the lowest of record for May. On the morning of the 16th an energetic low center was northeast of Montana with looped isobars extending to the southern limits of the district. In expectation of the eastward movement of the HIGH from the middle Pacific coast frost warnings were issued for Utah and western Colorado. This warning was verified in localities.

On May 22 high pressure overlay Wyoming and the Dakotas, while relatively low pressure prevailed in the Southwest. Warnings of frost were issued for eastern Colorado and northern New Mexico; but the HIGH moved toward the east and it is probable that frosts, if they occurred, were exceedingly light. On the morning of the 31st a low pressure area overlay New Mexico, and high pressure Montana and Wyoming. Warning of frost was issued for northeastern Colorado. At Denver the temperature reached 33°F., the lowest of record for June.—*Frederick H. Brandenburg, District Forecaster.*

San Francisco forecast district.—No marked storms moved in over this district from the ocean during May, but many depressions formed over the southern Plateau, causing cloudy and showery weather. Several of these depressions developed into quite severe storms after they crossed the Rockies. Light showers, mostly confined to the mountain and foot hill sections, were of frequent occurrence and thunderstorms accompanied by heavy rainfall occurred in the upper Sacramento Valley on the 25th. The forecasts of showers were more successful than the charts indicated, as most of the rain fell in sections from which reports are not received.

Killing frosts were forecast for Nevada on the 3d, 5th, and 16th, all of which were verified.

Northwest warnings were displayed at Point Reyes on the 24th, and a velocity of over 70 miles an hour occurred.—*G. H. Willson, District Forecaster.*

Portland, Oreg., forecast district.—Although May is generally a pleasant month in this forecast district, the weather this year was cooler than usual, due to the abnormal amount of cloudiness. The rainfall was nearly normal. During most of the month well-developed high-pressure areas lay over the North Pacific Ocean, while moderate low-pressure areas were present the greater portion of the time over the intermountain region and Southern Plateau States. This distribution of pressure gave the usual northwesterly winds, but the proximity of the disturbances to the southeastward and over the eastern portion of the district resulted in making this the cool, rainy month mentioned above. Night temperatures did not go very low, as a rule, but cloudiness prevented the usual afternoon "warming up" on fair days.

No storm warnings were issued during the month, and none were needed. One live-stock warning was sent out on the 8th, and as weather conditions changed very little during the remainder of the month, no other warnings were issued. This information was timely, and the service is, we believe, appreciated by the stockmen and farm-

ers. Forest Supervisor W. W. Cryder, of Pendleton, has written this office:

> The stockmen and farmers have come to regard your predictions as extremely valuable and necessary to their business. I want you to feel that they appreciate very much what you are doing for them. We all know what a difficult season you have had to contend with, and understand clearly the reason why more forecasts have not been issued.

Fortunately, there were no very cold spells, and the principal losses to the stockmen were on account of scarcity and high prices of feed, some stock succumbing on account of lack of sufficient nourishing food.

Frost warnings were issued on 8 dates. Of these 5 were for general frosts, light west of the Cascade Mountains and heavy to the eastward, and 3 were for local frosts. In western Washington and northwestern Oregon the warnings were generally failures, due to continued cloudiness; while most of the remainder were verified in part only, some were wholly accurate. Heavy frost occurred locally at Baker, in the Blue Mountains of northeastern Oregon, on the 16th, 19th, and 20th, without warning; and on the 16th an unforeseen minimum temperature of 30°, without warning, was reported from the Rogue River Valley, but fruit had reached such an advanced stage that no injury resulted.—*T. Francis Drake, Assistant Forecaster.*